Snow, ice and water carved the landscape of Hellespontus Montes

10 July 2014

The richly varied terrain of Hellespontus Montes on Mars is showcased in these images, acquired by the High Resolution Stereo Camera (HRSC) operated by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) on board ESA's Mars Express spacecraft. On the western edge of the huge Hellas Planitia impact basin, traces can be seen of the icy streams that once flowed here.

Hellas Planitia is the largest impact crater on Mars – a gigantic, slightly oval depression between eight and nine kilometres deep and up to 2200 kilometres across. The basin was created by the impact of a several-hundred-kilometre asteroid – the repercussions were not merely regional, but affected the entire planet.

The uneven ridge that runs around the rim of the basin – Hellespontus Montes – is the result of the final stages of the formation of the Hellas Planitia impact basin. This rough chain of mountain-like terrain was likely formed when the crater walls, pushed outwards by the tremendous forces following the impact, subsequently collapsed and sank towards the interior, developing the noticeable terraced pattern. Over time, erosion and weathering, as well as various small impacts, altered the terrain on the rim of Hellas Planitia, producing a landscape with an assortment of features. The area shown on the images extends for just under 180 kilometres from north to south by 75 kilometres from east to west, making it roughly the same size as Montenegro.

Typical for Mars – the wind causes erosion and heaps material into dunes

The images reveal interesting landscape features. Partially eroded sedimentary layers fill the largest impact crater. Portions of these layered rocks were subsequently eroded away – the layers that remained now form numerous flat-topped hills and outliers that were able to better withstand the weathering caused by the Martian wind. Some outliers act as wind breaks, producing smaller crescent dunes arranged like strings of pearls on the lee side (top left in images 1, 3 and 5).

The shape and alignment of these chains of dunes indicate that the wind blew mainly from the east, drifting from the lowland plains of Hellas (below, in the image) to the adjacent highland plains of Mars in the west. More dune fields, some of them substantially larger, are distributed across the image – barchan and crescent dunes, dome dunes and linear dunes that stretch out in long lines.

Also conspicuous are numerous valleys that have been carved into the smooth, slightly undulating surface. Following the slope, they point in the direction of the Hellas basin in the east. Here, the surface consists of deposits, laid down over the existing structures like a blanket. They most likely held large quantities of volatile elements such as water or ice. A few of the more precipitous slopes show traces of less compacted material that has slowly slipped off.

Snowfall in the early days of Mars likely caused the emergence of glaciers

Unusual, convoluted surface structures are visible within some of the smaller craters. Mars geologists speak of 'concentric crater fill' and conclude that, here too, the rock is mixed with ice. These deposits were exposed to substantial pressure – the plasticity of the ice lent the material a certain flowability, allowing it to move downwards towards the crater floor in a manner not

dissimilar to glaciers covered by a large quantity of rocky detritus, adapting themselves to the contours of the landscape as they passed.

Studies conducted on rock glaciers here on Earth (the ratio between ice and rock debris is around four to one), together with the known proportionality between the diameter and depth of a crater and the height to which the crater is filled, make it possible to estimate effective ice volumes. It is likely that the ice that flowed in these 'rock glaciers' was several hundred metres thick, and hence comparable with those found on Earth.

It is possible that the remnants of the ice are still trapped beneath a surface layer of dust and boulders that measure just a few tens of metres in thickness; indeed, some scientists consider it likely. Regular snowfall in the planet's early days, which accumulated around the peaks of the mountains on the ridge of Hellas basin, could explain the presence of ice in this region of Mars – located far from the South Pole. The atmosphere was probably denser then than it is today, and the humidity may well have been greater. The concentric lines visible in the crater fill are likely to be a consequence of the accumulation of snow and ice over many snowfall and freezing cycles. The rock glaciers located within the crater depressions were protected against sublimation, the process of transition from a solid state to a gaseous phase, for long periods.

Image processing

The HRSC (High Resolution Stereo Camera) images were acquired on 13 January 2014 during Mars Express orbit number 12,750. The image resolution is roughly 17 metres per pixel. The centre of the image is located at approximately 41 degrees south and 45 degrees east. The region takes its name from the historic term for the Dardanelles, a strait between the Aegean and the Sea of Marmara; in Greek mythology, Helle was the daughter of the Boeotian King Athama.

The colour plan view (image 1) was acquired using the nadir channel, which is directed vertically onto the surface of Mars, and the colour channels; the oblique perspective view (image 2) was derived from data acquired by the HRSC stereo channels. The anaglyph (image 3), which produces a three-dimensional impression of the landscape when viewed through red-blue or red-green spectacles, was derived from the nadir channel and one stereo channel. The colour coded plan view (image 5) is based on a digital terrain model of the region, from which the landscape topography can be derived.

The HRSC experiment

The High Resolution Stereo Camera was developed at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and built in collaboration with partners in industry (EADS Astrium, Lewicki Microelectronic GmbH and Jena-Optronik GmbH). The science team, which is headed by principal investigator (PI) Ralf Jaumann, consists of 52 co-investigators from 34 institutions and 11 countries. The camera is operated by the DLR Institute of Planetary Research in Berlin-Adlershof. The images presented here were created by the Planetary Sciences Group at the Freie Universität Berlin.

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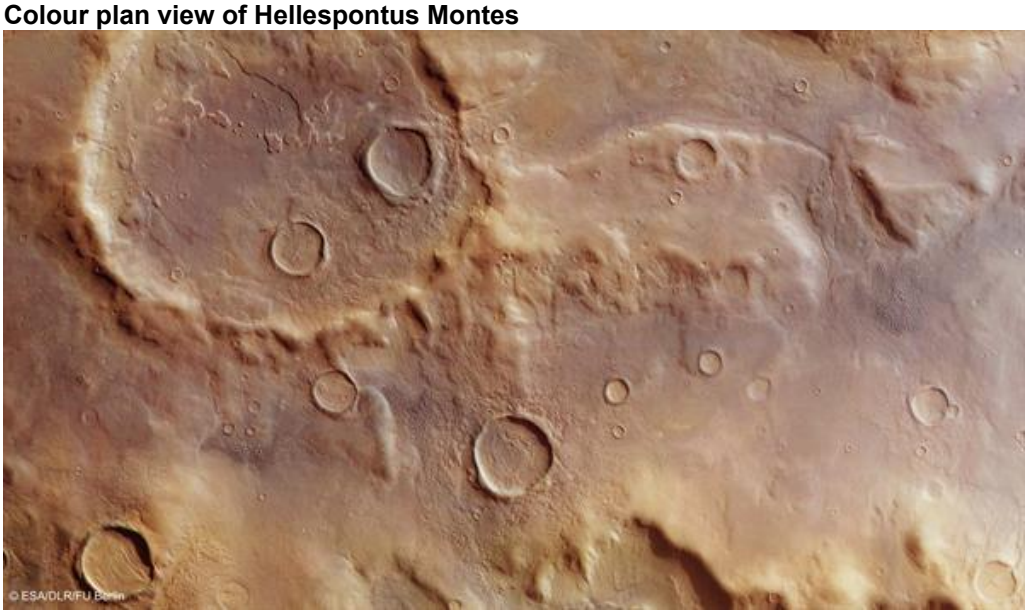
Colour plan view of Hellespontus Montes



The area shown here on the eastern edge of the Hellas impact basin extends for 180 by 75 kilometres – almost the size of Connecticut. A crater in the left (southern) half of the image dominates the scene; it is roughly 50 kilometres across, filled with sediment and already exhibits pronounced alteration due to erosive forces. Rivers have carved several valleys into the landscape situated further north. Lines of dunes, formed by the effect of wind blowing from the east, are found in several places. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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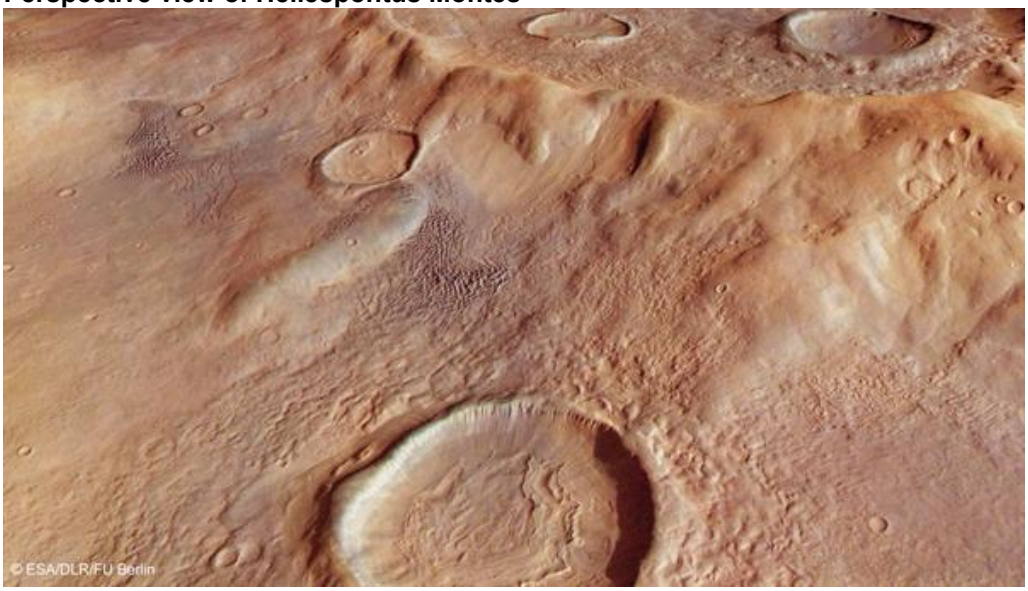
Perspective view of Hellespontus Montes



The presence of snowfall in the mountains situated on the western reaches of Hellas Planitia was likely in the early days of Mars. The precipitation compacted to ice that formed glaciers, which, exposed to natural pressure, started to flow and were covered by dust from the atmosphere as well as boulders and detritus. This sluggish mass of ice spilled into the crater depressions like thick porridge, forming deposits with the peculiar patterns shown here in the foreground, known as concentric crater fill. In addition, the left half of the image depicts several expanding, significantly younger fields of dunes. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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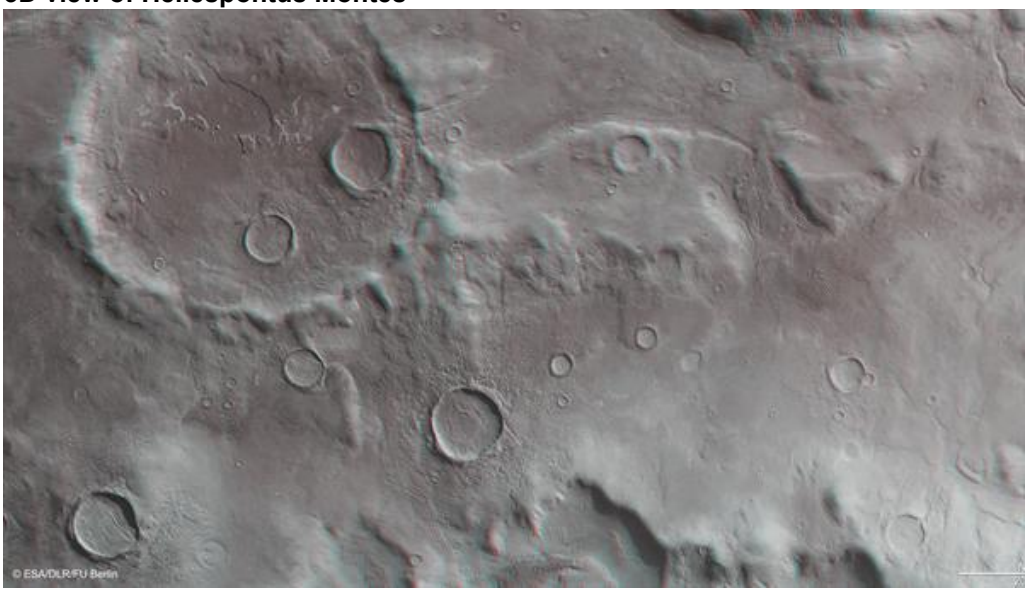
3D view of Hellespontus Montes



The nadir channel, which is directed vertically down onto the surface of Mars, and one of the four stereo channels in the DLR-operated HRSC camera system, can be used to create anaglyph images, which produce a realistic, three-dimensional view of the landscape when viewed with red/blue or red/green glasses. This gives a beautiful view of the landscape's terraced structure. The high image resolution of 17 metres per pixel shows even the smallest topographical details such as dunes, rock slides, individual layers in the craters and small gorges. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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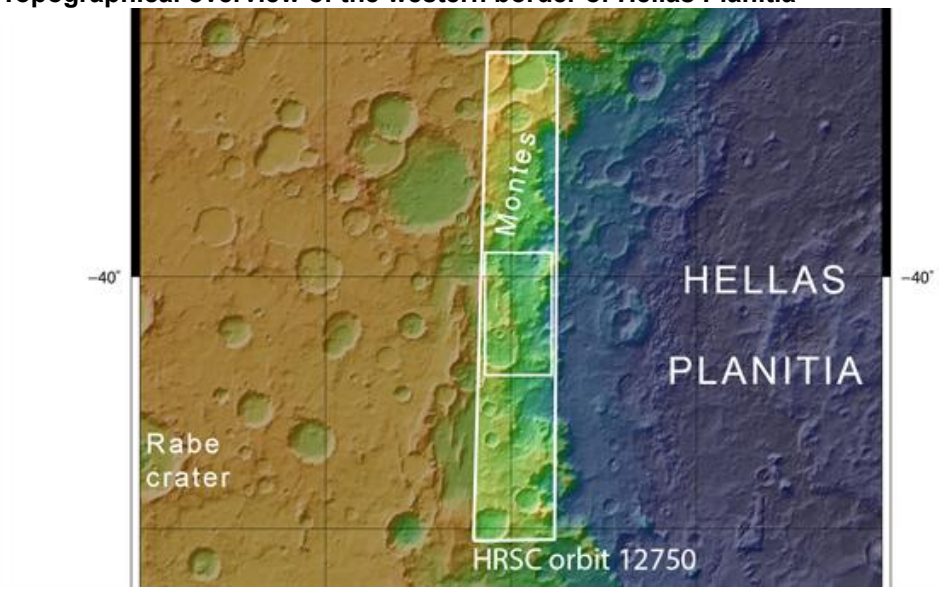
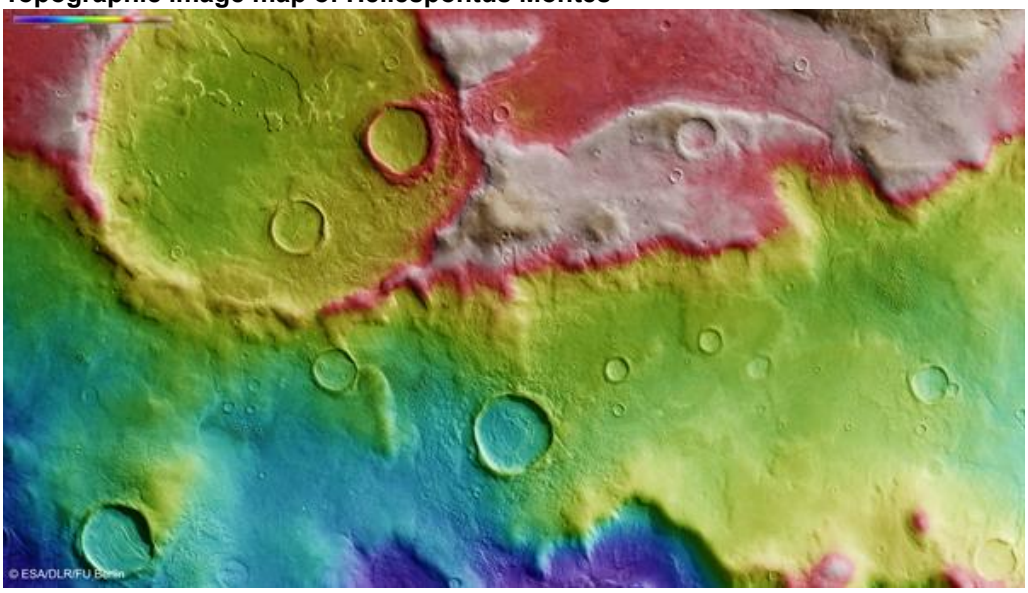
Topographical overview of the western border of Hellas Planitia



At around 2200 kilometres across in some places, Hellas Planitia is the second largest impact basin in the inner Solar System. The crater has a depth of eight kilometres. Following impact, the crater rim subsided into the Hellas depression along geological fault lines, producing the distinctive structures found in Hellespontus Montes. Mars Express imaged the region during orbit 12,750 on 13 January 2014. The landscape shown in the images presented here is situated in the smaller, inner rectangle within the image strip recorded by the DLR-operated High Resolution Stereo Camera (HRSC).

Credit: NASA/JPL/MOLA; FU Berlin.

Topographic image map of Hellespontus Montes



Topographic terrain models can be computed using stereo image data from the HSRC camera system, which is operated by DLR. This colour-coded image shows that three different elevations dominate the region in Hellespontus Montes. First, the blue base of the impact basin in the east (lower edge of the image) can be seen, followed by a terrain level located roughly 1500 metres higher and coloured in shades of green; finally, another plateau located over 1000 metres higher in red and greyish brown is visible. The colour coding permits the acquisition of information regarding erosion in the various impact craters. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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